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A PRELIMINARY CLASSIFICATION OF ANTICYCLONES BY MEANS OF THE THICKNESS PATTERN

BY J. S. SAWYER, M.A.

With the recent increase in the number of upper air soundings, thickness charts are employed by the weather forecaster to an increasing extent in determining the likely development of the synoptic situation (see Sutcliffe[1*]). Considerable success has been achieved in forecasting the behaviour of depressions in this way, and the significance of several types of thickness pattern which may occur over depressions is recognised. This note contains a preliminary classification of the main types of thickness patterns which occur over anticyclones; the classification is neither complete nor final, but is thought to be sufficiently well established to provide useful practical guidance in many synoptic situations.

In order that the cases examined should be reasonably clear cut, the study was confined to anticyclones which could be identified by 4-mb. isobars over a 24-hr. period. The centre was also restricted to lie between latitudes 40° and 60°N. and longitudes 0° and 50°W., *i.e.* over the eastern North Atlantic or seaboard of western Europe.

Classification of anticyclones.—In relation to the pattern of the 1000–500-mb. thickness lines the majority of anticyclones appear to fall into three types with distinct thickness patterns; a fourth type is also suggested, but the number of cases is insufficient to establish it with certainty. About one quarter of the examples fell into none of the four types. The behaviour of each type of anticyclone had certain broadly recognisable characteristics; these are set out below together with the thickness patterns which form the basis of the classification. How far these generalizations are justified may be assessed from Tables I–III in which the motion and change of intensity of the anticyclones are tabulated according to type. The tables contain two sets of data; the first, for the period October 1946 to April 1948, formed the basis of the classification; the second, May to September 1948, was analysed subsequently by Mr. A. G. Matthewman and may be regarded as an independent check of the validity of the classification. An entry is included in the tables for each 24-hr. period over which any anticyclone persisted in the area covered.

*These numbers refer to the list of references on p. 93.

The classification proposed is as follows.

Type 1—*Open wave type* (see Fig. 1).—The features of the thermal field are:—

(*a*) Strong thermal wind over the centre (usually 40–50 kt. over the range 1000–500 mb.)

(*b*) Flat " wave " pattern of thickness lines with the anticyclonic centre between a " thermal ridge " and the next " thermal trough " in the direction of the thermal wind (for this purpose a " flat " wave pattern may be regarded as one in which the maximum inclination to the general stream is less than 45°).

The simultaneous behaviour of the centre is:—

(i) Fast motion towards the " thermal trough ". The average speed is about 25 kt. but varies over a wide range; motion is in a direction roughly perpendicular to the trough line but there appears to be a tendency to move toward the region where the thermal wind is strongest.

(ii) Central pressure may rise or fall slowly; possibly, rising pressure is slightly more frequent.

Type 2—*Distorted wave type* (see Fig. 2).—The features of the thermal field are:—

(*a*) Strong thermal wind over the centre; usually 40–50 kt. when taken over the range 1000–500 mb.

(*b*) a " wave " pattern of wide amplitude in the thickness lines with the anticyclonic centre between a " thermal ridge " and the next " thermal trough " in the direction of the thermal wind. The difference between this type and the preceding type is in the distortion of the wave pattern which should twist the thickness lines to an angle of more than 45° from the general stream, *i.e.* from the general direction of the thickness lines over a wide area over which the distortion in the region of the anticyclone can be ignored.

The simultaneous behaviour of the pressure centre is:—

(i) Slow motion (10–25 kt.) towards the " thermal trough ". The direction is usually inclined to the right of the perpendicular to the trough line, but involves displacement across the thickness lines into the cold air.

(ii) Central pressure changing little or rising slowly.

Type 3—*Warm anticyclone* (see Fig. 3).The features of the thermal field are:—

(*a*) Very weak thermal gradients near the anticyclonic centre.

(*b*) Anticyclonic centre lies on or near the axis of the warm tongue.

The characteristic behaviour is:—

(i) Very slow motion (usually less than 10 kt.).

(ii) Direction of motion usually in a direction between the axis of the warm tongue towards the higher temperature and the direction from the anticyclone centre to the apex of the cold trough.

(iii) Little change in central pressure.

Type 4—*Difluent ridge type* (see Fig. 4).This type is not clearly defined because of lack of examples. Its main features are similar to Type 3 but it differs in that the next thermal trough is advancing towards the anticyclone centre. The thermal gradient is intensified on this side of the warm ridge and weak on the other.

The motion of the centre is in a similar direction to that of Type 3 but quicker (15–20 kt.); the central pressure decreases, sometimes rapidly.

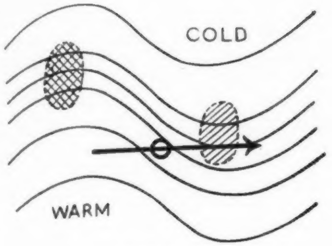
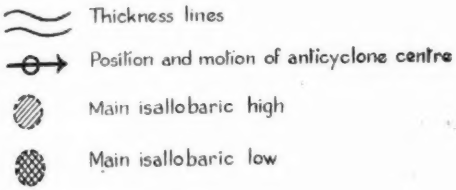


FIG. 1



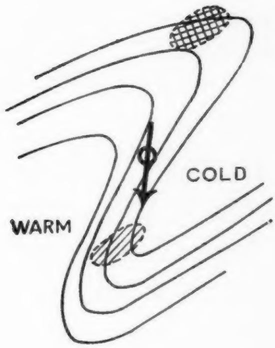


FIG. 2

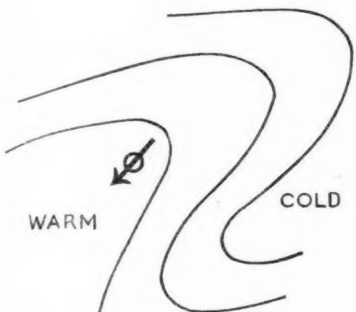


FIG. 3

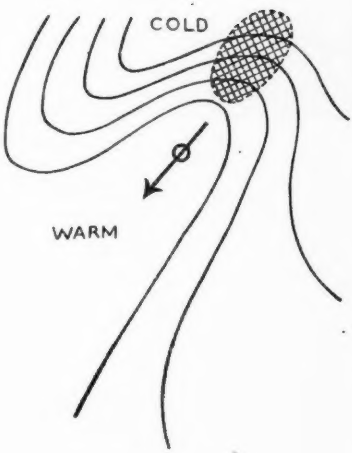


FIG. 4

Discussion of the results.—By the choice of area, cold polar and continental anticyclones have been excluded; so also have the subtropical highs when in their normal position.

The restriction to centres defined by 4-mb. isobars over a 24-hr. period also excluded, among others, those in the early stages of anticyclogenesis and the late stages of dissolution. Of the remainder, about three quarters could be classified according to the scheme now proposed.

The behaviour of the various types is explicable on the theoretical basis of Sutcliffe[2]. The classification is also consistent with the older conception of "cold" and "warm" anticyclones (Brunt[3], Douglas[4]). The transformation

TABLE I—NUMBER OF CASES IN WHICH ANTICYCLONES OF VARIOUS TYPES MOVED DISTANCES WITHIN CERTAIN RANGES

(*a*) Number of anticyclones in period October 1946 to April 1948
(*b*) Number of anticyclones in period May to September 1948

Type of anticyclone	Distance moved in 24 hr. (nautical miles)							
	0–150		150–350		350–550		Over 550	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
1	0	0	4	0	8	0	11	2
2	5	2	6	3	6	3	1	0
3	14	4	14	5	3	0	0	0
4	1	0	0	0	2	0	3	0
Unclassified	7	2	5	4	3	3	4	3

TABLE II—NUMBER OF CASES IN WHICH CHANGE OF CENTRAL PRESSURE FELL WITHIN CERTAIN RANGES

(*a*) Number of anticyclones in period October 1946 to April 1948
(*b*) Number of anticyclones in period May to September 1948

Type of anticyclone	Change in central pressure in 24 hr. (mb.)					
	−3 or less		−2 to +2		+2 or more	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
1	3	1	15	1	5	0
2	2	1	12	6	4	1
3	8	0	19	9	4	0
4	2	0	4	0	0	0
Unclassified	5	1	11	8	3	3

TABLE III—NUMBER OF CASES OF ANTICYCLONES WITH MOTION DIRECTED IN CERTAIN QUADRANTS WITH RESPECT TO THE THERMAL FIELD

(*a*) Number of anticyclones in period October 1946 to April 1948
(*b*) Number of anticyclones in period May to September 1948

Type of anticyclone	Direction (degrees)*									
	Indeterminate†		+45 to −45		−45 to −135		−135 to +135		+135 to +45	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
1	0	0	19	1	4	0	0	0	0	1
2	5	3	10	2	2	2	0	0	1	1
3	14	3	8	2	6	1	0	0	3	3
4	1	0	0	0	5	0	0	0	0	0
Unclassified	7	4	5	5	1	3	4	0	2	0

*Direction is measured with respect to a line drawn perpendicular to the main trough and ridge lines of the thermal field, the positive direction being taken in the direction of the thermal wind.

†Includes all cases of 150 nautical miles or less motion in 24 hr.

of a "cold" moving anticyclone into a slow-moving "warm" anticyclone can be regarded as a transition from Type 1 through Type 2 to Type 3. The recent classification due to Seilkopf[5] is broadly similar to the present one, but includes additional types.

No attempt is made here to draw general conclusions with validity outside the limited area and types of situation studied; however, the evidence supports the view that while "thermal steering" may be applied broadly to anticyclones in well defined and sensibly straight thermal patterns, it can be seriously misleading in other cases. The same generalization is known to be true for depressions.

Acknowledgement.—I wish to acknowledge the assistance given by Mr. A. G. Matthewman in the preparation of this paper and in particular his analysis of the anticyclones of the period May to September 1948; also the help given by Miss D. L. Barnes in collecting the data.

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SEASONAL WEATHER SEQUENCES OVER ENGLAND AND WALES

By J. GLASSPOOLE, M.Sc., Ph.D.

While it is well known that dry winters may be followed either by dry, average or wet summers, no table is readily available showing the frequencies of such occurrences. The estimates of general monthly rainfall over England and Wales, which are available back to 1870, provide the material for preparing such a table and this note sets out the results of examining these records. The general monthly values, as published in the annual volumes of *British Rainfall*, are the best available estimates of the mean rainfall over the country, *i.e.* the estimated mean depth in inches of the varying rainfall amounts over the various districts. The monthly values in inches were grouped to give the total amount in each meteorological winter, defined as covering December to February; in each spring—March to May; in summer—June to August; and in autumn—September to November. The rainfall of each season was regarded as "average" when it was within 5 per cent. of the mean, "wet" when from 105 to 130 per cent., and "very wet" when more than 130 per cent. of the average. Similarly the limits 95–70 per cent. and less than 70 per cent. were used to denote "dry" and "very dry".

In Table I details of the nature and frequency of the springs, summers and autumns following the five different types of winters are listed for the 79 years December 1869 to November 1948.

The table shows that there is very little difference in the rainfall types of either the spring, summer or autumn following winters which were very wet, wet, average, dry or very dry. The subsequent seasons gave less rather than more than the average, when the preceding winters were very wet, average or dry in the case of springs; average, dry or very dry in the case of summers, and wet or dry in the case of autumns. This again indicates that the rainfall of the following seasons is not determined by the rainfall of the winter. The table brings out that dry winters have been followed by dry springs, summers and autumns, rather more often than by wet ones.

The results are in accord with an earlier examination* of the persistence of dry or wet months, when the general conclusions were: (*a*) runs of five or more months, either all above or all below the average, are rather more frequent

*BILHAM, E. G.; Sequences of dry and wet months in England and Wales. *Quart. J. R. met. Soc., London*, **64**, 1938, p. 324.

TABLE I—OCCASIONS OF SEASONAL RAINFALLS FOLLOWING WINTERS OF DIFFERENT TYPES

Winters		Spring	Summer	Autumn
Very wet (12 cases)	very wet	1 } 4	1 } 6	1 } 6
	wet	3 }	5 }	5 }
	average	2	2	0
	dry	5 } 6	3 } 4	5 } 6
	very dry	1 }	1 }	1 }
wet (20 cases)	very wet	2 } 9	2 } 10	2 } 5
	wet	7 }	8 }	3 }
	average	3	3	5
	dry	8 } 8	4 } 7	9 } 10
	very dry	0 }	3 }	1 }
average (11 cases)	very wet	1 } 2	2 } 4	2 } 5
	wet	1 }	2 }	3 }
	average	2	1	2
	dry	4 } 7	1 } 6	1 } 4
	very dry	3 }	5 }	3 }
dry (25 cases)	very wet	2 } 8	3 } 7	3 } 10
	wet	6 }	4 }	7 }
	average	5	4	2
	dry	9 } 12	9 } 14	10 } 13
	very dry	3 }	5 }	3 }
very dry (11 cases)	very wet	2 } 7	2 } 4	1 } 5
	wet	5 }	2 }	4 }
	average	1	2	1
	dry	3 } 3	3 } 5	5 } 5
	very dry	0 }	2 }	0 }

than chance would indicate; and (*b*) runs of three or more dry months are distinctly more frequent than runs of three or more wet months.

Similar general values for temperature for England and Wales are available only since 1901*. The general values of temperature, as published in the *Monthly Weather Report*, are obtained by taking the mean of the departures from average at 30 well distributed stations and applying these means to the general monthly mean temperatures computed for England and Wales. In the following table, months with temperatures within 0·5°F. of the average are counted as " average ", months with an excess of 2°F. as " much above " and with temperatures of 2°F. below the average as " much below ".

Table II shows that the temperatures of the springs, summers and autumns following winters of the various types have had on the whole no special characteristics. It will be noticed, however, that following the 14 cases of winters with temperatures " above " average, the summers were rather more often colder than average and the autumns rather more often warmer than average.

The winter of December 1948–February 1949 falls into the classification adopted here of " dry " as regards rainfall, and " much above " as regards temperature. Table I shows that of 25 earlier cases of " dry " winters the following spring was " dry " or " very dry " on 12 occasions, the following

*GLASSPOOLE, J. and HOGG, W. H.; Serial monthly values of mean temperature over the British Isles, 1881–1940, and annual values 1866–1940. *Quart. J. R. met. Soc., London*, **69**, 1942, p. 45.

TABLE II—OCCASIONS OF SEASONAL TEMPERATURES FOLLOWING WINTERS OF DIFFERENT TYPES

Winters		Spring		Summer		Autumn	
much above (7 cases)	much above	1	3	0	3	0	2
	above	2		3		2	
	average	1		1		3	
	below	3	3	3	3	1	2
	much below	0		0		1	
above (14 cases)	much above	1	4	1	4	1	7
	above	3		3		6	
	average	7		3		5	
	below	3	3	6	7	0	2
	much below	0		1		2	
average (14 cases)	much above	0	4	1	5	1	6
	above	4		4		5	
	average	4		3		2	
	below	6	6	6	6	3	6
	much below	0		0		3	
below (6 cases)	much above	1	1	0	2	1	2
	above	0		2		1	
	average	2		2		2	
	below	3	3	2	2	2	2
	much below	0		0		0	
much below (7 cases)	much above	0	1	1	3	1	3
	above	1		2		2	
	average	3		1		4	
	below	1	3	2	3	0	0
	much below	2		1		0	

summer on 14 occasions and the following autumn on 13 occasions, *i.e.* on half the occasions. Table II shows that of the 7 earlier cases of winters with temperatures " much above " average, the following springs, summers and autumns had no marked tendency as regards temperature.

Table II shows that there were 21 winters classified as " much above " or " above " with regard to temperature, and of these we find that seven were also " dry " or " very dry ". The classification of the seasons following these seven winters is given in Table III.

TABLE III—SEASONAL CHARACTERISTICS FOLLOWING MILD AND DRY WINTERS

		Spring		Summer		Autumn	
Rainfall	very wet	1	3	2	2	2	4
	wet	2		0		2	
	average	1		1		0	
	dry	2	3	2	4	2	3
	very dry	1		2		1	
Temperature	much above	0	5	1	5	0	3
	above	5		4		3	
	average	1		0		3	
	below	1	1	2	2	1	1
	much below	0		0		0	

We see therefore that in these cases the subsequent springs, summers and autumns each varied between very wet and very dry. This was mainly due to the fact that these seven winters include both those of 1902–03 and 1920–21, the one followed by the notoriously wet 1903 and the other by the unprecedentedly dry 1921, again confirming that the rainfall and temperature of the

winter, as classified here, does not give any indication of the weather characteristics of the following seasons. Table III does, however, show a notable preponderance of temperatures above average in each season following mild and dry winters.

The only earlier occasion during the present century when the winter was classified as both "dry" and "much above", as in 1948–1949, was that of 1920–21. This is widely remembered as being followed by an exceptionally dry and hot summer. Before jumping to any conclusion, concerning the prospects for the summer of 1949, we carry out a cautious comparison of the monthly values of these two winters, without finding any close similarity.

TABLE IV—COMPARISON IN ENGLAND AND WALES OF WINTERS 1920–21 AND 1948–49

Winter	General rainfall Dec.	Jan.	Feb.	Mean departure from average temperature Dec.	Jan.	Feb.
		inches			*degrees Fahrenheit*	
1920–21	3·7	4·3	0·4	+0·5	+5·3	+1·1
1948–49	4·4	1·7	1·5	+2·0	+2·1	+2·6

There is not therefore any justification in concluding that the summer of 1949 will resemble that of 1921. Indeed Nature seems capable of producing an infinite variety of sequences, and no indication has been found of any repetition likely to be of service in forecasting.

METEOROLOGICAL RESEARCH COMMITTEE

At the sixth meeting of the Physical Sub-Committee, held on May 19, the Sub-Committee heard with regret the resignation of Dr. Sutherland following his appointment to a chair of Physics at Michigan University.

A paper by Mr. R. F. Jones[1] dealing with the heights and temperatures at the tops of radar echoes associated with various cloud systems was discussed. Another paper by Dr. Frith[2] dealing with some measurements of cloud particle size in strato cumulus clouds was also discussed.

Mr. Shellard presented a paper[3] which summarises the results of the measurement of humidity at high levels on all ascents to date by the Meteorological Research Flight.

A note[4] on an empirical formula for the terminal velocities of raindrops was also considered.

The fifth meeting of the Instruments Sub-Committee was held on May 26. The Sub-Committee considered the possible use of "window" and of ionised clouds—in conjunction with radar—for the measurement of winds at great heights.

It was decided to try to adapt the Dobson-Brewer frost-point hygrometer for use on the ground.

Papers considered included one by Dr. Harrison[5] dealing with the uncertainty of radar wind smoothing on ocean weather ships and a paper by Mr. Ashford[6] on the development of marine meteorological instruments.

[1] *Met. Res. Pap., London,* No. 458.
[2] *Met. Res. Pap., London,* No. 472.
[3] *Met. Res. Pap., London,* No. 486.
[4] *Met. Res. Pap., London,* No. 469.
[5] *Met. Res. Pap., London,* No. 477.
[6] *Met. Res. Pap., London,* No. 481.

OFFICIAL PUBLICATIONS

The following publications will shortly be issued:—

GEOPHYSICAL MEMOIRS

No. 83—*Wind at* 100,000 *ft. over south-east England.* Observations and a discussion of the monsoon theory of wind at great heights. By R. J. Murgatroyd, B.Sc.(Eng.) and C. J. B. Clews, Ph.D.

This memoir describes a series of 35 measurements of the wind at 100,000 ft. over south-east England in 1944–45 by observations of the drift of smoke produced by shell bursts from a high-velocity gun. The results indicate that the wind was mainly strong SW.–NW. in winter and moderate NE.–SE. in summer, with light winds during the change-over in spring and autumn. The mean temperature values up to 60,000 ft. from 1942 to 1945, obtained from radio-sonde ascents over Salisbury Plain and the Shetlands, indicate that in winter it is colder to the north and in summer warmer to the north; this explains the seasonal variation of wind direction in the stratosphere. The relationship between the horizontal temperature gradients, the vector mean winds over the British Isles and the wind values at 100,000 ft. are also discussed.

No. 84—*Atmospheric electricity during disturbed weather.* By Sir George Simpson, K.C.B., F.R.S.

From October 1942 to May 1946 a special investigation of atmospheric electricity during disturbed weather was undertaken at Kew Observatory with special reference to the electricity carried by rain and snow. The chief results may be summarised under three headings:—

(*a*) *Potential gradient and weather.*—Although the potential gradient is generally disturbed during rain or snow the disturbance is not primarily controlled by the amount or rate of the rainfall, but appears to depend on the presence of ascending currents in the upper atmosphere. Although the variations of the potential gradient during disturbed weather are usually quite irregular there are periods when the gradient plotted against time shows regular patterns which take the form of harmonic waves or of oscillations symmetrical about the mid-point of the pattern. The cause and origin of these patterns is unknown.

(*b*) *The electricity carried by the precipitation when the potential gradient exceeds* $|20|$ v./cm.—It is found that when the gradient exceeds $|20|$ v./cm., the charge on the rain and snow is opposite in sign to that of the potential gradient, and that the charge and the gradient increase and decrease together. It is suggested that this is because the electricity carried by the precipitation is mainly derived from the point-discharge current which originates on all pointed objects when exposed to a potential gradient greater than $|20|$ v./cm. The precipitation appears to sweep up ions from the point-discharge current as suggested by C. T. R. Wilson; but there are difficulties in this explanation for the charge observed is greater than would be expected on Wilson's theory.

(*c*) *The electricity carried by the precipitation when the potential gradient is less than* $|10|$ v./cm.—Low potential gradients are usually associated with light steady rain, the gradients being less than the normal fine-weather gradient and generally negative. The rain electricity in such circumstances is practically always positive and the charge per cubic centimetre is directly proportional to the depression of the gradient below its normal fine-weather value. With steady snowfall below the freezing point the gradient remains normal and the charge on the snow negative.

ROYAL AERONAUTICAL SOCIETY

Radar as an aid to the study of the atmosphere

It is well known that one of the bodies which made a great contribution to the development of radar equipment during the war was the Telecommunication Research Establishment (T.R.E.), a department of the Ministry of Supply. One of their most successful devices was that known as "Oboe", a blind aircraft navigation and bombing system used by the Pathfinders, for the development of which Dr. F. E. Jones was largely responsible. After the war T.R.E. began the process of beating their swords into ploughshares by considering possible applications of radar to meteorology, and they have been co-operating with the Meteorological Office in several projects.

A lecture on this work was given by Dr. Jones at a meeting of the Royal Aeronautical Society on January 27, 1949.

Including pulsed visible and ultra-violet light techniques in the term radar, Dr. Jones described the results achieved and hoped for under five main headings: detection of precipitation and cloud; measurement of cloud height; measurement of density in the upper atmosphere; measurement of wind; and measurement of pressure, temperature and humidity.

It is about seven years since radar echoes from rain were first observed, and a great deal of work has been and is being done on the use of radar as a means of investigating conditions within precipitating clouds and of obtaining warning of the approach of storms and rain-belts. It has been shown theoretically by Ryde that the energy scattered by a water drop is proportional to the sixth power of the diameter. If, therefore, the distribution of drop sizes were a function of the rate of rainfall, and if the function could be determined, the radar echo intensity would be a measure of the rate of rainfall. This is found to be true on the average, and data correlating drop-size distribution with rate of rainfall have been compiled by Laws and Parsons. Dr. Jones described a series of measurements made by T.R.E. on echoes from rain*, using a radar beam directed vertically upward, on a wave-length of 3·2 cm., in which the echo intensity as a function of precipitation rate agreed very well with that calculated from Laws and Parsons' data, using Ryde's theory.

In the same series of experiments observations of the so-called "bright band" were also made. This is the name given to a strong echo returned from a layer slightly below the freezing level. It has been explained by Ryde and by Hooper as being due to partially melted snowflakes, which give a stronger echo than unmelted ice crystals but have a lower speed of fall and therefore a higher concentration than water drops.

The intense convection in cumulonimbus clouds, which is such a serious danger to aircraft, produces large raindrops and therefore strong radar echoes. It is thus of interest to find out whether radar can be used to investigate the mechanism of these clouds and also to give warning of their proximity. In 1946, a party from T.R.E. flew to Singapore in a Lancaster equipped with a 3·2-cm. radar and made a study of the matter. As a result of their observations a cloud warning radar for aircraft has been designed by T.R.E. and is to undergo extensive trials. A specimen was shown at Dr. Jones' lecture.

*Part of this work was done at Larkhill radio-sonde station.

Since the distance of rain can be measured by radar, it might be thought that here was a valuable means of measuring the height of a cloud base from the ground, a problem of great practical importance for aviation. This, however, is not so, for, since the echo intensity returned by water drops of a given size is inversely proportional to the fourth power of the wave-length of the radiation, cloud droplets, which are of the order of one hundredth of the diameter of raindrops, do not normally give an observable echo even on the highest radio frequencies that can be produced.

T.R.E. have under development a cloud-height meter working on the radar principle but using one-microsecond pulses of visible light produced by a spark. This promises to be a most valuable piece of equipment. If successful, it will have a great advantage over the cloud searchlight in not requiring a base-line.

Another project for the use of pulsed light is the measurement of the density of the upper atmosphere, at heights beyond the reach of radio-sonde balloons, by observation of the energy scattered by the air molecules. This idea is being developed by the Radar Research and Development Establishment, another department of the Ministry of Supply.

Many meteorologists will be on more familiar ground in the last two applications of radar to meteorology discussed by Dr. Jones, namely the measurement of wind and of temperature and humidity in the upper atmosphere. Radar methods of wind measurement are in general use by the Meteorological Office, in conjunction with a radio-sonde working on a wave-length of 11 m. T.R.E. have under development a combined equipment, the radar-sonde theodolite, consisting of an airborne transmitter working on a wave-length of 10 cm., with a radio-theodolite for the measurement of azimuth and elevation, and a recorder for pressure, temperature and humidity, the changing values of which will be signalled by some form of pulse system instead of the sinusoidal modulation in use at present. Range will be measured by an outgoing pulse from the ground on a wave-length of 2 m., which will be picked up by a receiver carried by the balloon, and this in turn will trigger the airborne transmitter and cause it to send a pulse back to the ground. Thus the airborne receiver and transmitter, together known as a responder or transponder, will take the place of the radar reflector now used, which will enable much greater ranges to be obtained. Flight trials have shown that the responder can be followed easily to a range of 100 miles.

An interesting feature of the responder is the thermally insulating container of expanded rubber. This is so effective that during a long flight into the stratosphere at night the heat produced by the battery and circuits is enough to maintain the internal temperature constant within a few degrees. This will have two important results: first, a saving of battery weight, since the performance of the battery falls off rapidly with falling temperature; second, the prospect of an improvement in the accuracy of pressure measurements through the placing of the pressure unit inside the case.

The radio-theodolite will follow the movement of the balloon automatically, and it is hoped that it will also be taught trigonometry and the differential calculus and will present its findings in the form of a record of wind direction and speed synchronised with the record of pressure, temperature and humidity.

In initiating the discussion after the lecture, Sir Robert Watson-Watt recalled the early days of radar, and declared the spirit of its present-day exponents to be worthy of the pioneers. Many others contributed to the discussion with suggestions of needs (chiefly in relation to flying) requiring to be met and of problems awaiting investigation. One speaker made a plea for a simplification of units—feet, yards, miles and metres, Centigrade and Fahrenheit—with which many of us will sympathise.

The lecture has been published in the *Journal of the Royal Aeronautical Society* for May 1949.

D. N. HARRISON

ROYAL METEOROLOGICAL SOCIETY

Waves and swell

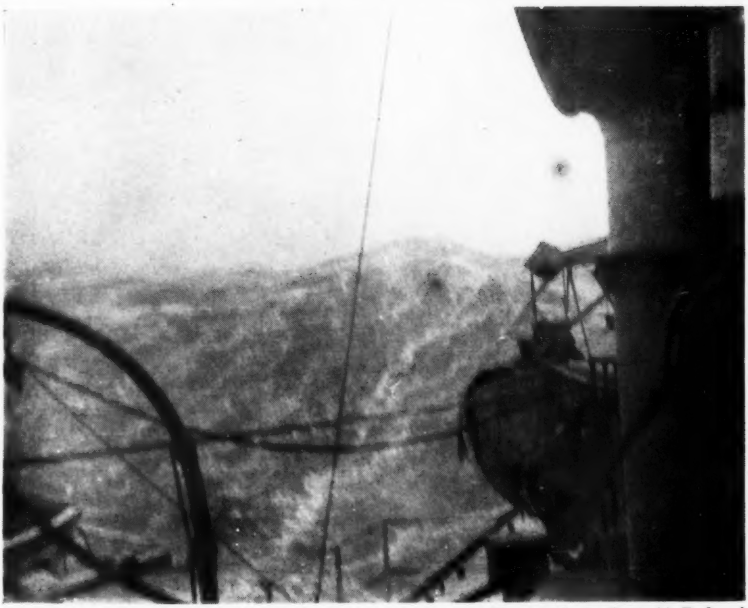
At the meeting of the Society, held at 49 Cromwell Road, on April 20, 1949, Sir Robert Watson-Watt, President, in the Chair, the Symons Memorial Lecture was delivered by Dr. G. E. R. Deacon on the subject " Waves and swell ".

Dr. Deacon began his lecture by remarking that interest grew in the subject during the war when it became necessary to forecast the behaviour of landing craft on a beach due to the presence of surf and swell. The bulk of the work was then done under the Director, Naval Meteorological Service, by Inst. Cdr. C. T. Suthons, and is being followed by long-term research.

Until recently waves and swell had been observed almost entirely by visual methods, the main difficulty being the lack of any stationary surface; steoroscopic methods had been used but they were very laborious. Methods now consist of placing a suitable distant-recording instrument on the sea bed in 40–100 ft. of water and measuring either the pressure (which depends on depth of water, period and height of wave) or sound echo between the instrument and the sea surface, thus measuring wave height. A long wave record did not give a simple wave pattern and it was necessary to analyse the record into its component simple waves.

Dr. Deacon showed slides illustrating the instruments in use, including the frequency analyser; he also showed how two wave-trains of almost similar periods combine into groups of waves. With the frequency analyser it is possible to record the individual wave periods electrically and so recognise the long low waves, which could be traced to individual storms far out in the Atlantic. Slides were shown of an analysis of the waves arriving every two hours between March 14 and March 16, 1945, at Peranporth near Lands End. The long waves arrived first becoming progressively shorter; they were traced to a storm near Newfoundland on the 11th and 12th. Another example shown was of long, long-period waves which were observed from May 4 to May 19, 1946; these must have come a distance of 7,000 miles, *i.e.* from the South Atlantic. They also exhibited a periodic frequency change of about 12½ hours showing the effect of the tides.

Dr. Deacon went on to discuss the wave characteristics set up by different wind speeds and showed that the smaller-period waves lost energy to the longer-period waves up to a maximum for any given wind speed; this was studied by observation, from aircraft, of waves in the Irish Sea when a steady



Photographs by Capt. N. F. Israel

STATE OF SEA AT THE CENTRE OF A DEPRESSION

The above photographs were taken aboard O.W.S. *Weather Observer* while on Station JIG (53° 50′N. 18° 40′W.) on March 31, 1948. The weather ship was situated near the centre of an intense depression and reported winds of near hurricane force. The upper photograph was taken at about the centre of the depression and gives an impression akin to that of the "eye" of a tropical storm with the typical "pyramidal" sea, the wind having eased temporarily. The lower picture was taken at the height of the storm some little distance from the centre.

GENERAL VIEW OF THE W/T RECEPTION ROOM AT CENTRAL FORECASTING OFFICE, DUNSTABLE

GENERAL VIEW OF THE W/T RECEPTION ROOM AT CENTRAL FORECASTING OFFICE, DUNSTABLE

A W/T OPERATOR TYPING OUT THE MESSAGE AS RECEIVED

To face page 201]

SWELL PRECEDING A TROPICAL STORM

This swell was approaching the Bahamas from a West Indian hurricane. Note that the swell waves are long, low and long-crested. The wind is blowing almost at right-angles to the direction of motion of the swell (*i.e.* parallel to the crests), as is made clear by the breaking of sea waves in the foreground.

26-kt. wind was blowing. He thought it was possible to predict the main details of waves that would reach a coast although it was not possible to predict all the details, the secondary waves being due to wind variations and not a random distribution reaching the coast.

Dr. Deacon discussed, with slides, the effect of shallows, headlands and inlets on waves, showing how the waves tended to bend and become parallel to the coasts, to retard and break with an ebb-tide, to hasten and lengthen with a flood-tide, to alter with irregularities of the sea floor, and to be reflected by steep walls. Waves began to break when the depth of water became less than four thirds of the wave height; the shortening of wave-length and consequent heightening of the long, low, swell waves as they approach a coast was the primary cause of what was known at sea as ground swell. Although the swell would be present out at sea it would be too low and too long to be noticed.

Among meteorological conclusions Dr. Deacon mentioned the approach of long-period waves some 6–12 hours before the approach of a cyclone to Japan, that long waves travelled with gradient wind speed, that the longest wave-period was a measure of the strongest wind, and that the interference of waves of the same period could produce microseismic waves.

At the President's suggestion it was decided to break with the tradition of the Symons Memorial lecture and have a discussion—if Dr. Deacon agreed.

Dr. Slater asked if there was any significance in the ratio of length of waves to their height being normally over 13; because, if it were less than 13, then two waves of almost similar periods would combine to produce waves of ratio less than $6\frac{1}{2}$ which would therefore break.

Inst. Cdr. Suthons remarked that waves broke when the angle at the crest became less than 120° as had been verified in tanks. It depended on each individual wave.

Mr. E. Gold had recently been able to measure wave periods by eye observation only and had timed waves of 14 and 16 sec. on successive days; the swell was of great regularity on the east coast of South America. What was meant by depth of water—mean depth or depth from trough or crest? Dr. Deacon agreed that waves were sufficiently regular for eye observations in the southern hemisphere but it was difficult when a long swell was obscured by a short swell. It was Sverdrup who had found the breaking ratio from many examples using the mean depth.

Mr. T. H. Kirk remarked on the difficulties of observing swell at sea and of the distinction drawn between the state of sea which was caused by the wind and the swell which was caused by waves from a distance. According to an I.M.O. resolution at Washington, observers had been asked to measure the height of swell but it would take many observations to measure the mean swell. We could make climatic charts of swell provided observations were consistent; he would like Dr. Deacon's opinion of the future of observations of swell from ships. Dr. Deacon said the charts, which had proved useful during the war, would be better with new methods of observation. When research had come to the stage of being useful others could carry on with it. Work had been done in the past by the French and New Zealand authorities—the North Atlantic was the place to do research because of the good meteorological network there.

Sir Robert Watson-Watt thought Dr. Deacon was a bit choosey over the scatter of his observations; they were not so scattered as the normal meteorological observations he had had to use.

ROYAL METEOROLOGICAL SOCIETY
THE "SIR NAPIER SHAW" COMPETITION

To commemorate the work of Sir Napier Shaw the following prizes are being offered for 1949:—

Junior section.—Age 15 to 21.

1st Prize value £5, 2nd Prize value £3, 3rd Prize value £2.

Subject.—The best description of any weather phenomena actually witnessed at any time by the entrant. The description should be as short as possible and in any case less than 1,000 words in length, and if possible should be illustrated by a sketch or photograph.

Senior section.—Open to any entrant not a professional meteorologist,

1st Prize value £10, 2nd Prize value £5.

Subject.—The best description, photograph, film or drawing (or combination thereof) of any of the following actually witnessed by the entrant:—

Any meteorological phenomena associated with earthquakes or volcanoes.

Any lightning storm or series of lightning storms.

Any cloud phenomena of the rarer sort such as a "Sydney Buster", a "Pampero" or a "Haboob", or sand devils in a desert.

The clouds associated with any tornado or waterspout.

An example of "St. Elmo's Fire".

The effect of any meteorological factor(s) on agriculture, industry or any industrial process, or on any public utility.

The effect of any meteorological factor(s) on plant, insect, or bird life.

Any optical meteorological phenomenon except a rainbow.

Rules

(1) The submission must be in English and, if possible, typed. All drawings and diagrams should be in lead pencil on smooth paper 10 in. × 8 in.

(2) All photographs to be as sharp and as full of gradation as possible, with good contrast. Prints should be glossy and in black and white.

(3) Copyright of submissions gaining prizes to become the property of the Society.

(4) Name and Address to be given in block letters on each entry.

(5) The Society will endeavour to return all unsuccessful work provided a stamped addressed envelope of suitable size is sent.

(6) The Society's decision shall be final and no correspondence can be entertained.

(7) Entries must be addressed to: "Sir Napier Shaw" Competition—Royal Meteorological Society, 49 Cromwell Road, London, S.W.7.

(8) Latest receiving date for the 1949 competition: Home entrants—September 30, 1949; Overseas entrants—October 15, 1949.

(9) Submission of an entry will be deemed to indicate acceptance of these rules. There are no entrance fees and no application forms, but entrants for the Senior Section must include with their entry a certificate that they are not professional meteorologists.

(10) Prizes will be withheld if a sufficiently high standard is not attained.

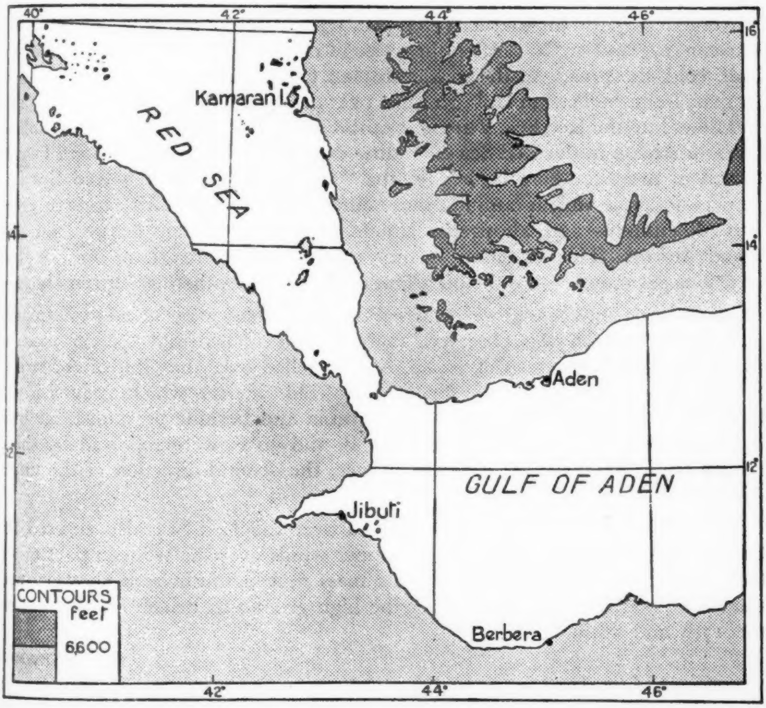
The results of the competition will be announced in *Weather*, the popular monthly magazine published by the Society.

LETTERS TO THE EDITOR

Waterspout seen from Kamaran Island, Red Sea

The following interesting eye-witness account of a waterspout was received from Major D. Thompson, Civil Administrator, Kamaran Island.

He states: "On Saturday, October 16, 1948, at 0800 G.M.T., there were signs in the south-east of an approaching storm. Heavy dark clouds veered towards the island and by 0830 the cloud base over Kamaran Bay at about 1,000 ft. At this time Kamaran itself was not particularly affected. Heavy peals of thunder were heard but there were no vivid flashes of lightning which usually prevail in such storms. By 0845 slight rain fell on Kamaran and the dark clouds began to spread over the southern and centre portions of the island. At 0855, while thunder prevailed, a dull detonation, rather like the sound of gun-fire at a distance, was heard. The sound came from almost due east but slightly south of the island. At first, I considered one of the buildings in the Lazaretto, particularly the water storage tanks which stand on masonry, had collapsed or that one of the 120-ft. wireless masts had fallen down. This impression was gained because of the impact of something very heavy on ground. Immediate examination proved the tanks, masts and other buildings intact. The phenomenon then occurred. Emerging from the clouds at about 1,000 ft. and east of Kamaran, a long trail or spiral of black smoke was seen. The column had a positive downward motion and was cork-screwing, almost in snake-like



fashion, at an angle of roughly 45° and entered the sea in Kamaran Bay 300 yd. east of Kamaran coastline opposite the old Turkish water tower, which is 3 miles north of the Lazaretto. To the naked eye, the column appeared to be about 2½ ft. in diameter right from cloud emergence to point of entry in the sea. At this point the sea was 'boiling' over an area—again to the naked eye—of roughly 35 ft. in diameter. The downward trend of the column continued for fully five minutes when the storm broke over the island. Torrential rain fell, the wind reached gale force (force 7) and the sea became obscured in heavy mist blotting out further observation of the column which had, when last seen, changed colour from back to very dark grey. The storm lasted for an hour and a quarter; slightly over three quarters of an inch of rainfall was recorded.

"As the storm cleared, having swung round from SE. to NE.—almost completing a semicircle—smoke or vapour of the 'coal-tar' colour was observed emerging from the sea at the point already described. It reached a height of about 200 ft. at sea level carried by the wind (or probably propelled by currents in the sea) and gave the impression of a trail of smoke moving northwards at about 25 m.p.h. on the surface of the sea. By 1030 the smoke (or perhaps vapour) had entirely disappeared."

The thunderstorms which developed over the southern Red Sea on October 16, 1948, moved north-westwards to affect the coasts of Eritrea and the Anglo-Egyptian Sudan on October 17 and 18. It is of interest to note that throughout most of the winter period (October to March) there is a " front " or " line of convergence " over the southern Red Sea, lying approximately west to east and between 17° and 14°N. After the passage of a depression down the Persian Gulf, cold air spreads to the south Arabian Coast and then westwards. This air mass from the Persian Gulf, warmed over the Arabian Sea, becomes unstable and flows into the Red Sea. The same outbreak of cold air gives rise to a shallow NW. air stream in the Red Sea extending down to or beyond Kamaran Island. Ascent of the " southern " air over the " northern " air in the Red Sea can on occasion give violent cumulus and cumulonimbus clouds with tops merging into altocumulus and altostratus clouds, and moderate or heavy rain and thunderstorms. This situation occurs rarely—not more than one or two occasions per month—and the occasions of very bad weather are extremely rare.

On October 16, 1948, however, when the thunderstorm occurred at Kamaran and the waterspout was observed, there is no evidence that the air mass in which the thunderstorms developed, had travelled over the Gulf of Aden into the Red Sea. The storm developed in the cold air mass which arrived in the Red Sea from the Persian Gulf across Arabia and became very unstable over the warm sea. Sea temperatures of 93°F. and 90°F. were reported by ships. Except for a shallow layer near the surface, the general direction of the upper winds over the Red Sea was from SE.

The same cold air mass which arrived over the Red Sea also entered the Gulf of Aden from the East, but the upper winds over the western part of the Gulf were from NNE. and as the air mass moved southwards showery and thundery conditions developed over the high ground in British Somaliland on the 17th and 18th.

C. C. NEWMAN

Khormaksar, Aden, December 3, 1948

Description of the synoptic situation

In a note* published in *Nature*, Sir Napier Shaw remarked that the " concentration of attention upon centres of high or low pressure, which are practically points of no motion, instead of upon the air-currents which cause them, is a curious aberration of dynamics."

Now it is not suggested that the modern forecaster concentrates his attention exclusively on the centres of pressure patterns on his synoptic chart. Unlike his predecessor of 30 years ago, who had little or no current upper air data and was therefore largely restricted to thinking two dimensionally, the forecaster of today may have quite an appreciable amount of upper air information for each main synoptic hour, and may thus be able to supplement his surface chart with upper air charts for several levels together with vertical cross-sections; he can, in fact, form a three-dimensional picture of the weather situation.

Nevertheless, phrases mainly related to the surface chart are still used to describe the synoptic situation in very much the same way as they were 30 years ago. A depression and an anticyclone are still referred to as physical entities and mention is often made of the acceleration or retardation of their centres. We know, of course, that the majority of forecasters do not suffer from the "aberration " to which Sir Napier Shaw referred, but, on the other hand, they would probably find it very difficult to describe, three-dimensionally, the changes in the circulation in precise and intelligible language.

In his note Sir Napier Shaw referred to pressure gradient as " the deformation of an isobaric surface from the horizontal by the shifting of air-mass ", and, emphasising the enormous release of energy by condensation, he asserted that "the real dynamical agents of the free air are the currents which find their cartographical expression as the straight isobars running between high pressure and low pressure." Maybe, in the course of time, a new phraseology for describing the synoptic situation will be developed and will be related to the position, stability, movement (both horizontally and vertically), and interaction of the air masses involved. In fact, there are already indications of this in the forecast information issued by the Central Forecasting Office.

R. G. VERYARD

MED./M.E., December 4, 1948

[Modern synoptic meteorologists generally think in terms of interrelated variables rather than in terms of cause and effect, unless there is an undoubted time sequence. Three-dimensional treatment is already leading to an expansion of our vocabulary, and this will be developed further. Nevertheless it is likely that depressions and anticyclones will continue to occupy the primary place in our descriptive terminology. They should be regarded as three-dimensional systems of organization of atmospheric motion, with special relation to vertical movement and the associated convergence and divergence. There seems to be no reason for regarding a pressure system as either less or more of a physical entity than an air current or an air mass. All are abstractions, to be used as circumstances require.

Sir Napier Shaw's remarks, quoted by Mr. Veryard, were based more especially on very large air streams which are often associated with straight isobars, which in turn are related to the tendency for high- and low-pressure

*SHAW, SIR NAPIER; Potential temperature and the stratosphere. *Nature, London*, **127**; 1931, p. 971.

systems to become elongated or to develop in chain formations. It must be kept in mind that with parallel straight isobars, neglecting the rather obscure effect of latitude variation, a steepening gradient involves ageostrophic motion towards the falling pressure. If these conditions extend to all heights there is no known mechanism for the transference of air from falling to rising pressure. There is now overwhelming evidence that the air transferences, indicated by development in the field of sea-level pressure, are associated with patterns of motion in the upper troposphere different from those in the lower troposphere. If there is a large northerly current at low levels there is normally an upper trough over its eastern half, and similarly there is an upper wedge over the eastern part of a large southerly current.

Sir Napier Shaw emphasised different aspects of these problems at different times. In dealing with questions which must be to some extent speculative (and were more so in his day) it is more important to stimulate thought than to achieve perfect consistency. His work on travelling vortices published in a *Geophysical Memoir** and later in " Manual of Meteorology ", Part IV, attracted much interest at the time. Certain types of depression, especially old ones, do at least approximate towards rotating cylinders. Shaw showed that the centre of a moving vortex is separate from the isobaric centre and that the wind centre (*i.e.* the position of the momentary calm) is distinct from both. If the rotation is weak relative to the translation there is no closed isobar or region of calm. In the stronger currents aloft the absence of closed centres is of course more frequent, though the best examples of rotary systems extend to high levels.

The necessities of coding the baratic and prebaratic messages for distribution, and the close relation between the verbal parts of the technical bulletins and the coded parts, may tend towards the over-emphasis of closed sea-level isobars. Mr. Veryard is right to warn us of this danger, but the supreme importance of depressions and anticyclones as organisms remains unaffected. —C. K. M. DOUGLAS]

Dust devils at Dublin Airport

Dust devils are by no means rare in the subtropical desert regions, but they are extremely rare in the British Isles, and many people were probably surprised to see the report of " present weather = 08 " at Dublin Airport on the afternoon of May 12. The report was quite genuine, and the dust devil then seen was only one of several which occurred during the period May 7–13. Most of them, however, were too small to be considered worth reporting.

The dust devils developed on a part of the airfield from which the grass and top soil have been stripped to prepare for the laying of further concrete extensions to the apron and runways. During the previous weeks evaporation considerably exceeded precipitation, so that the ground was very dry. Constant traffic of lorries and excavators had pulverised the exposed surface until it was covered with very fine dust, two to three inches deep in places. This dust layer was very strongly heated by the sun: on the 7th a thermometer laid on the ground, with its bulb just covered by dust, showed 89°F., whereas the temperature a foot above the ground was only 54°F. and the screen maximum that day was only 51°F. !

*SHAW, SIR NAPIER; The travel of circular depressions and tornadoes. *Geophys. Mem., London*, 2, No. 12, 1917.

Most of the devils, which occurred only at irregular intervals, and during the hottest part of the day (1200–1530 G.M.T.) were small whirls up to about ten feet across, and lifting the dust to a height of no more than 50 ft. They showed cyclonic rotation and drifted with the wind until they moved off the dust area on to the grass, when they appeared to collapse, although the dust settled only slowly. I was present at the birth of one small devil, which was first evidenced by a blast of rising hot air and a slight swirl in the dust near by. The swirl grew horizontally rather than vertically and there seemed to be minor eddies circulating round the main centre.

The largest devil observed was at 1340 G.M.T. on the 12th, just as the SE. sea breeze became established after a short calm interval. The dust cloud accompanying a moving lorry suddenly extended in all directions with almost explosive violence. Dust and loose grass were sucked up from an area 20 yd. across. The tufts of grass rose no more than 20 ft., but, in a period of less than a minute, the dust column shot up to a height which some estimated to be as much as 200 ft. By the time the maximum height was reached the base was decaying on the grass.

F. E. DIXON

Dublin Airport, May 18, 1949

NOTES AND NEWS

New type of anemometer

Among the instruments described in Messrs. Nash and Thompson's catalogue is a novel meteorological instrument, the wind velocity vector integrator. This instrument sums on four counters the wind drift in miles and tenths in the four cardinal directions.

The instrument has an anemometer head of the cup type driving a friction wheel mounted with a horizontal axis which, in turn, drives a sphere floating in mercury. The axis of the friction wheel is rotated in a horizontal plane by a wind vane so that the sphere rotates in the vertical plane containing the wind direction at a speed proportional to the wind velocity. Four small friction wheels bearing on the sphere at the cardinal points of its equatorial plane pick up the components of angular velocity of the sphere and actuate a counter by closing contacts.

This instrument attracted much attention when shown at the Physical Society's 1949 exhibition of scientific instruments.

Tellus

We welcome the arrival of the new quarterly journal, *Tellus*, of the Swedish Geophysical Association.

It will contain original contributions in all branches of geophysics and will be edited by Professor C.-G. Rossby.

The first number sets a very high standard. It contains papers by H. Pettersson on the deep ocean bed samples obtained on the recent *Albatross* oceanographic expedition, by T. Bergeron on cloud physics, by E. Palmén on the structure of high level cyclones, by A. Nyberg on an aerological study of large-scale atmospheric disturbances, and C. G. Rossby on the dispersion of planetary waves in a barotropic atmosphere.

Copies of the journal have been ordered for the Meteorological Office Library and the Technical Libraries at Victory House and Dunstable.

REVIEW

Neue Methoden der Wetteranalyse und Wetterprognose, by R. Scherhag. 8vo. 11¾ in. × 8¼ in., pp. xii+424. Springer-Verlag, Berlin/Göttingen/Heidelberg. 1948. Price *DM*. 80.

This monumental work is the most important book on forecasting to appear since the publication of Petterssen's " Weather analysis and forecasting " and Chromov's " Einfuhrung in die synoptische Wetteranalyse "*. Both these books were published in 1940 and the main difference between Scherhag's book and them is the great increase in the attention paid to upper air analysis.

The author was released early in 1944 from routine forecasting in the German Central Forecast Office to write a book describing the new methods, developed in the Reichsamt für Wetterdienst during the war, to utilise the much increased amount of aerological data. It is a book on weather forecasting, not, as is so often the case, one on thermodynamical and dynamical meteorology with some application to forecasting.

The book is in five parts.

Part I is entitled " Development and bases of synoptic meteorology ". As the title implies, it is partly historical but the most important part of it is devoted to methods of constructing contour charts of standard isobaric surfaces and the advantages of such charts. The standard isobaric surfaces used are those for 1000, 500, 225, 96 and 41 mb. and were selected because, over central Europe, the thicknesses between each pair are nearly the same. Part I also contains a short account of dynamical and thermodynamical theory which, in the reviewer's opinion, could have been omitted, as any reader able to use such a book as this would certainly know more than is given in it.

Part II deals with the " General circulation of the troposphere and stratosphere and its effect on weather ". The major part of it is concerned with mean contour and thickness charts for the northern hemisphere. Much of the data used for constructing these charts is naturally only for short periods, only months in some cases. The mean contours for the 41-mb. level are particularly interesting with the change from a low between the North Pole and Siberia in January to a high over the same region in July. Much of the data for the Arctic used in compiling these charts was obtained by stations maintained by the Germans for part of the war on Greenland, Spitsbergen and Franz Josef Land. Some indication of the degree of accuracy claimed for the charts and for winds measured from them with the nomogram provided would have been useful. It is by no means clear what data were used in the construction of the charts except over Europe and the parts of the Arctic mentioned above.

Part III entitled " The weather and its analysis " contains detailed analyses of many different types of European weather situations and is probably the most valuable part of the book. Never before have so many synoptic " specimens " been assembled within the covers of one book. In the case of more recent examples the upper air charts are naturally given as well as the surface ones. Older charts have been re-plotted and re-analysed. Cold pools are dealt with for the first time in a text-book with a detailed description of the outstanding one of January-February 1944. Criticisms are that many of the charts are too crowded for legibility, and that a more numerical statement of

*German translation of Russian original, first edition 1934, second edition revised and enlarged, 1937.

air-mass properties might have been provided on the lines of Schinze's 1932 paper on the subject.

Part IV is called " The weather forecast " and is very practical in outlook. A novel feature is a list of meteorological changes difficult to forecast, with instances of forecasts which proved seriously wrong and the reasons why. Much useful advice for the forecaster is given, such as that it is better to issue a forecast on a well analysed earlier chart than to prepare one hastily from data that has just come in. Numerous rules for the application of upper air charts are given together with methods for the preparation of " prebaratic " charts. The part ends with advice on the matters to be considered in forecasting individual elements such as visibility, and on means of estimating the value of a forecast.

Part V is a sketch of long-period forecasting methods. The author regards the synoptic method as useful only up to three days. For longer periods the author thinks that consideration of the kinds of change of weather most likely at particular times of year (singularities), and the study of pressure waves have their uses. The possible effects of sunspots and of volcanic dust are also considered.

An appendix contains tables for finding the heights of the standard-pressure levels, some transformations of units, and a table for finding an approximate value of the 16-Km. wind over Germany from the 11-Km. wind.

The documentation is excellent. There are detailed tables of contents and of illustrations and indexes for both subjects and names. There is a bibliography of 897 items.

The book is certainly one which should be studied by every synoptic meteorologist possessing a moderate knowledge of German.

G. A. BULL

NEWS IN BRIEF

It was announced in the Birthday Honours List, June 1949, that Professor David Brunt, F.R.S., has been created Knight Bachelor by H.M. the King, and that Mr. F. D. Napier, Senior Instrument Maker in the Meteorological Office has been awarded the British Empire Medal.

WEATHER OF MAY 1949

Mean pressure for the month was between 1020 and 1025 mb. over the extreme northern parts of Canada, in the north-east of Greenland, at Spitsbergen, and at Horta, and between 1005 and 1010 mb. over southern Algeria and part of the Sahara. It was nearly normal in North America and two or three millibars below normal over most of central and western Europe.

Broadly speaking, the weather over the British Isles was wet in the southern half of the country and over a part of west Scotland and rather dry on the whole elsewhere. It was sunny in most areas apart from the north-west of Scotland and locally in east England, while the mean temperature was somewhat below the average in the south and rather above the average in the north.

A belt of high pressure extending from the Azores to southern Scandinavia maintained fair weather generally during the first three days of the month;

screen frost occurred locally in England on the 1st, a minimum of 28°F. being recorded at Mildenhall. On the 4th a depression south-west of Iceland moved to the north of Scotland and an associated trough moved south-east over the British Isles, while on the 6th a small depression west of Scotland moved quickly east-south-east. Rain occurred on the 4th and scattered showers on the 5th, while fairly general rain was associated with the depression on the 6th. On the 7th and 8th an anticyclone was situated westward of Ireland; subsequently it moved in over the British Isles where it remained until the 12th and throughout this period fair weather prevailed, with abundant sunshine in most districts. Screen frost occurred again locally in eastern districts on the 8th and 10th; on the latter date 28°F. was recorded at Wittering and 29°F. at Finningley.

A change to unsettled conditions with local thunderstorms occurred on the 14th and persisted for the most part until the end of the month. On the 15th a complex area of low pressure over France and central Europe extended over the British Isles causing local thunderstorms in England. On the 16th a depression approached south-west England from the west and subsequently moved north-east and then north to a position off the north of Scotland by the 19th; general rain and local thunderstorms occurred on the 16th and 17th and scattered rain and a few local thunderstorms on the 18th and 19th. On the 20th a ridge of high pressure developed over the British Isles and later moved slowly east; it was associated with a short fair spell, with good sunshine records in the west and north on the 20th, over most of Britain on the 21st and in eastern districts of Britain on the 22nd. Local thunderstorms occurred, however, in the eastern half of England on the 20th.

Unsettled weather was renewed on the 23rd when a depression off west Scotland moved slowly east-north-east and a small associated secondary moved quickly north-east over southern England giving fairly heavy rainfall in south and east England during the night of the 23rd–24th. On the 27th a depression off north-west Ireland moved irregularly north-north-east and an associated trough moved east over England and Wales; heavy rain fell in Wales and western districts of England, amounting to more than 2 in. at numerous stations (2·93 in. at Machynlleth, Montgomery, 2·77 in. at Rushworth Lodge, West Riding of Yorkshire, 2·69 in. at Hafod Fawr, Merioneth, and 2·64 in. at Rochdale, Lancashire). In the closing days an almost stationary depression was situated off the west of Scotland; weather was showery with local thunderstorms but long, sunny periods.

The general character of the weather is shown by the following provisional figures:—

	Air Tempertaure			Rainfall		Sunshine	
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average	Percentage of possible duration
	°F.	°F.	°F.	%		%	%
England and Wales ..	77	27	−0·4	112	−1	119	46
Scotland	75	24	+0·7	90	−1	112	38
Northern Ireland ..	72	32	0	90	0	117	42

RAINFALL OF MAY 1949

Great Britain and Northern Ireland

County	Station	In.	Per cent of Av.	County	Station	In.	Per cent of Av.
London	Camden Square ..	1·91	109	*Glam.*	Cardiff, Penylan ..	3·71	151
Kent	Folkestone, Cherry Gdn.	2·11	126	*Pemb.*	St. Ann's Head ..	2·18	108
,,	Edenbridge, Falconhurst	1·75	94	*Card.*	Aberystwyth	2·78	134
Sussex	Compton, Compton Ho.	2·34	105	*Radnor*	Tyrmynydd	5·91	172
,,	Worthing, Beach Ho.Pk.	1·45	88	*Mont.*	Lake Vyrnwy	4·67	138
Hants	Ventnor, Roy. Nat. Hos.	1·33	78	*Mer.*	Blaenau Festiniog ..	6·40	113
,,	Bournemouth	1·68	96	*Carn.*	Llandudno	1·87	105
,,	Sherborne St. John ..	2·79	144	*Angl.*	Llanerchymedd ..	1·77	75
Herts.	Royston, Therfield Rec.	2·24	115	*I. Man.*	Douglas, Borough Cem.	·92	37
Bucks.	Slough, Upton	2·32	138	*Wigtown*	Port William, Monreith	·84	36
Oxford	Oxford, Radcliffe ..	2·41	129	*Dumf.*	Dumfries, Crichton R.I.	1·88	68
N'hant.	Wellingboro', Swanspool	2·95	152	,,	Eskdalemuir Obsy. ..	3·28	99
Essex	Shoeburyness	1·79	138	*Roxb.*	Kelso, Floors	1·35	70
Suffolk	Campsea Ashe, High Ho.	1·94	129	*Peebles*	Stobo Castle	2·33	103
,,	Lowestoft Sec. School ..	1·67	104	*Berwick*	Marchmont House ..	1·83	74
,,	Bury St. Ed., Westley H.	2·19	120	*E. Loth.*	North Berwick Res. ..	1·90	95
Norfolk	Sandringham Ho. Gdns.	2·72	149	*Midl'n.*	Edinburgh, Blackf'd. H.	1·90	93
Wilts.	Bishops Cannings ..	2·63	135	*Lanark*	Hamilton W. W., T'nhill	1·79	75
Dorset	Creech Grange	2·47	121	*Ayr*	Colmonell, Knockdolian	1·71	67
,,	Beaminster, East St. ..	3·69	179	,,	Glen Afton, Ayr San ..	2·16	72
Devon	Teignmouth, Den Gdns.	2·18	119	*Bute*	Rothesay, Ardencraig	2·93	97
,,	Cullompton	2·71	125	*Argyll*	L. Sunart, Glenborrodale	3·42	96
,,	Barnstaple, N. Dev. Ath.	2·36	114	,,	Poltalloch	3·32	115
,,	Okehampton, Uplands	3·08	115	,,	Inverary Castle ..	3·83	97
Cornwall	Bude School House ..	2·21	120	,,	Islay, Eallabus ..	1·63	62
,,	Penzance, Morrab Gdns.	2·75	124	,,	Tiree	2·06	82
,,	St. Austell, Trevarna ..	3·17	131	*Kinross*	Loch Leven Sluice ..	2·34	96
,,	Scilly, Tresco Abbey ..	2·91	172	*Fife*	Leuchars Airfield ..	1·37	70
Glos.	Cirencester	2·83	137	*Perth*	Loch Dhu	3·47	77
Salop.	Church Stretton ..	3·23	127	,,	Crieff, Strathearn Hyd.	2·58	104
,,	Cheswardine Hall ..	2·36	107	*Perth*	Pitlochry, Fincastle ..	2·64	125
Worcs.	Malvern, Free Library	2·42	112	*Angus*	Montrose, Sunnyside ..	1·51	74
Warwick	Birmingham, Edgbaston	2·21	103	*Aberd.*	Braemar	1·79	75
Leics.	Thornton Reservoir ..	2·61	130	,,	Dyce, Craibstone ..	1·88	74
Lincs.	Boston, Skirbeck ..	1·92	109	,,	Fyvie Castle	2·22	86
,,	Skegness, Marine Gdns.	1·62	95	*Moray*	Gordon Castle	2·03	96
Notts.	Mansfield, Carr Bank ..	2·36	111	*Nairn*	Nairn, Achareidh ..	1·75	98
Derby	Buxton, Terrace Slopes	3·15	102	*Inv's*	Loch Ness, Foyers ..	2·18	89
Ches.	Bidston Observatory ..	2·86	151	,,	Glenquoich	4·73	86
Lancs.	Manchester, Whit. Park	3·47	164	,,	Fort William, Teviot ..	4·05	103
,,	Stonyhurst College ..	2·46	86	,,	Skye, Duntuilm ..	4·55	160
,,	Blackpool	2·68	123	*R. & C.*	Ullapool	1·96	80
Yorks.	Wakefield, Clarence Pk.	1·66	84	,,	Applecross Gardens ..	4·09	127
,,	Hull, Pearson Park ..	1·18	61	,,	Achnashellach	3·63	86
,,	Felixkirk, Mt. St. John	1·34	71	,,	Stornoway Airfield ..	2·50	103
,,	York Museum	1·80	90	*Suth.*	Lairg	..	..
,,	Scarborough	1·80	94	,,	Loch More, Achfary ..	4·91	112
,,	Middlesbrough	·89	46	*Caith.*	Wick Airfield	1·98	96
,,	Baldersdale, Hury Res.	1·44	56	*Shetland*	Lerwick Observatory ..	1·39	67
Norl'd.	Newcastle, Leazes Pk. ..	·54	27	*Ferm.*	Crom Castle	2·29	82
,,	Bellingham, High Green	1·10	46	*Armagh*	Armagh Observatory ..	1·79	75
,,	Lilburn Tower Gdns. ..	1·27	55	*Down*	Seaforde	1·75	67
Cumb.	Geltsdale	1·37	53	*Antrim*	Aldergrove Airfield ..	1·85	81
,,	Keswick, High Hill ..	2·84	89	,,	Ballymena, Harryville ..	2·31	81
,,	Ravenglass, The Grove	2·81	100	*L'derry*	Garvagh, Moneydig ..	2·04	80
Mon.	Abergavenny Larchfield	2·30	86	,,	Londonderry, Creggan	3·33	127
Glam.	Ystalyfera, Wern House	4·67	134	*Tyrone*	Omagh, Edenfel ..	3·28	127

CLIMATOLOGICAL TABLE FOR THE BRITISH COMMONWEALTH, JANUARY 1949

Stations	Pressure: Mean of day M.S.L.	Pressure: Diff. from normal	Temperatures: Absolute Max.	Temperatures: Absolute Min.	Temperatures: Mean values Max.	Temperatures: Mean values Min.	Temperatures: Mean values ½ Max. and Min.	Temperatures: Mean values Diff. from normal	Temperatures: Mean values Wet bulb	Relative Humidity	Mean Cloud Amount	Precipitation: Total	Precipitation: Diff. from normal	Precipitation: Days	Bright Sunshine: Daily Mean	Bright Sunshine: Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	oktas	in.	in.		hr.	%
London, Kew Observatory	1022·3	+5·4	53	28	47·1	37·4	42·3	+1·8	40·0	88	6·7	1·20	−0·56	12	1·8	21
Gibraltar	1022·9	+1·4	66	44	60·1	50·9	55·5	+0·6	51·0	79	4·6	2·32	—	7	5·3	54
Malta	1019·3	+2·3	65	41	59·3	49·2	54·3	−1·0	53·1	79	4·5	2·28	—	18	6·3	64
St. Helena	1014·1	−0·9	78	59	71·5	60·2	65·9	+2·2	60·9	97	7·7	0·33	−1·90	9	—	—
Lungi, Sierra Leone	1010·9	—	92	63	87·8	69·9	78·9	—	71·3	91	3·4	0·00	—	0	—	—
Lagos, Nigeria ..	1010·1	+0·4	96	66	91·8	70·7	81·3	+0·4	76·1	86	5·4	0·00		0	5·7	49
Kaduna, Nigeria ..	1010·0	—	97	55	89·0	58·6	73·8	+0·2	55·1	22	1·5	0·00	0·00	0	9·1	79
Chileka, Nyasaland	1009·9	−1·6	98	63	90·4	69·9	80·1	+5·0	69·4	64	3·7	1·20	−7·39	7	7·6	59
Lusaka, Rhodesia ..	1008·7	−1·0	95	61	86·4	64·3	75·3	+4·6	65·2	73	5·8	3·00	−7·35	14	8·9	69
Salisbury, Rhodesia..	1009·9	−0·9	90	54	81·8	60·7	71·3	+2·3	62·6	70	4·5	6·02	−1·69	14	8·2	63
Cape Town ..	1012·8	−0·6	87	52	79·4	62·6	71·0	+1·1	60·4	61	2·5	6·02	+5·34	4	—	—
Palmietfontein, S. Africa	1010·6	—	94	49	82·3	60·6	71·5	—	61·0	66	5·0	8·12	—	20	8·1	
Mauritius																
Calcutta, Alipore Obsy.	1015·4	−0·4	85	51	81·1	57·7	69·4	+2·8	59·7	88	0·8	0·05	−0·37	1	9·2	84
Bombay	1013·1	−0·5	91	65	86·3	68·8	77·5	+2·0	65·8	74	1·7	0·00	−0·10	0	9·0	81
Madras	1014·4	+0·3	86	64	83·4	67·2	75·3	−0·9	67·8	85	2·9	0·00	−1·14	0	10·0	88
Colombo, Ceylon ..	1011·5	+0·7	90	66	87·2	71·9	79·5	0·0	71·3	89	4·7	1·50	−1·75	7	7·7	65
Singapore	1011·3	+0·9	92	71	87·8	74·1	80·9	+1·2	74·6	77	5·4	7·91	−1·98	10	—	—
Hongkong	1021·8	+2·1	75	43	64·9	54·0	59·5	−0·7	53·3	68	—	0·08	−1·24	3	6·5	60
Sydney, N.S.W. ..	1012·6	+0·2	93	51	75·1	62·6	68·9	−2·7	63·7	67	5·0	10·80	+7·13	14	7·8	55
Melbourne	1013·2	+0·3	100	49	76·9	56·9	66·9	−0·5	58·4	56	4·7	1·34	−0·55	11	8·1	56
Adelaide	1014·4	+1·4	100	51	81·6	58·7	70·1	−3·6	58·9	43	4·0	0·24	−0·48	5	9·3	67
Perth, W. Australia	1012·7	+0·2	104	55	87·5	65·6	76·5	+2·7	65·1	51	4·0	0·20	−0·14	5	9·0	64
Coolgardie	1012·8	+1·4	108	53	90·2	63·4	76·8	−0·6	59·1	36	3·2	0·00	−0·46	0	—	—
Brisbane	1011·7	+0·4	95	64	84·3	67·9	76·1	−1·1	67·7	63	4·2	5·17	−1·28	8	9·5	69
Hobart, Tasmania ..	1012·3	+2·0	86	41	67·5	50·6	59·1	−2·9	54·0	61	6·2	4·20	+2·37	11	6·4	43
Wellington, N.Z. ..	1008·5	−3·6	76	44	66·5	52·3	59·4	−1·8	56·0	75	5·8	2·25	−1·08	13	6·3	43
Suva, Fiji	1007·4	−0·1	93	71	85·8	74·5	80·1	+0·2	76·6	86	5·9	21·38	+9·95	22	6·0	46
Apia, Samoa ..	1008·5	+1·0	89	71	86·9	74·5	80·7	+0·6	78·5	80	4·6	11·82	−5·94	16	7·9	62
Kingston, Jamaica ..	1016·1	+1·0	91	65	84·8	67·0	75·9	−0·9	70·7	72	1·9	0·02	−0·94	1	8·6	77
Grenada, W. Indies	—	—	91	69	86	71	78·5	+1·4	71	66	3·5	0·71	−3·67	14		
Toronto	1020·1	+2·2	52	9	35·0	23·3	29·1	+6·9	26·5	78	7·0	3·33	+0·54	14	1·5	16
Winnipeg	1023·6	+2·7	40	−43	7·3	−11·0	−1·9	+2·0	−3·8	—	4·3	2·04	+1·13	10	3·3	38
St. John, N.B. ..	1020·5	+5·0	50	−3	32·3	15·8	24·1	+4·9	19·4	88	5·3	5·71	+0·91	15	3·4	37
Victoria, B.C. ..	1026·9	+10·9	50	12	37·5	24·2	30·9	−8·1	28·1	88	5·2	0·69	−3·85	11	3·8	43